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STRESS ANALYSIS ON COMMERCIAL AIRCRAFT WINDOW BLEED (TINY) HOLE

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ABSTRACT

The paper deals with the stresses and stress concentration phenomenon around the window bleed hole of Airbus A380 aircraft. The Analytical solution of the stress concentrations is determined at different conditions using Finite Element Analysis ANSYS.

KEYWORDS: Airbus A380, Aircraft window, FEA & Stress Concentration

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Original Article

INTRODUCTION

Window seat of the aircraft is the favorite seat of almost all of us. The normal people will just see scenery from aircraft window. But, we aircraft nerds observe various things of aircraft such as movement of various elements of aircraft wings such as flaps, ailerons, aircraft engine, etc.

This small hole is known as breather hole or bleed hole. There are mainly two purposes of this hole

- Controlling moisture and
- Equalizing pressure difference

The small air gap is present between outer pane & middle pane. This tiny bleed hole lets moisture escape from air gap &prevent aircraft window by fogging up or by frosting. And let passengers enjoy the outer scenery.

As stated breather hole also helps to equalize the pressure difference. As aircraft ascends atmospheric pressure decreases&cabin pressure is maintained by the cabin pressure stabilizer system as outer atmospheric low pressure is not good for human health. This causes a pressure difference between the cabin and the atmosphere. This produces lots of physical stress on aircrafts window which can damage aircraft windows. So to prevent this damage breather hole is used. Breather hole equalizes the pressure difference between inner & outer aircraft window pane by releasing some amount of pressure in the air gap. So, outer pane takes lots of pressure & middle pane acting fail safe. The outer pane got damaged due to some reason air gets leaked from breather hole&prevent middle pane by damaging.

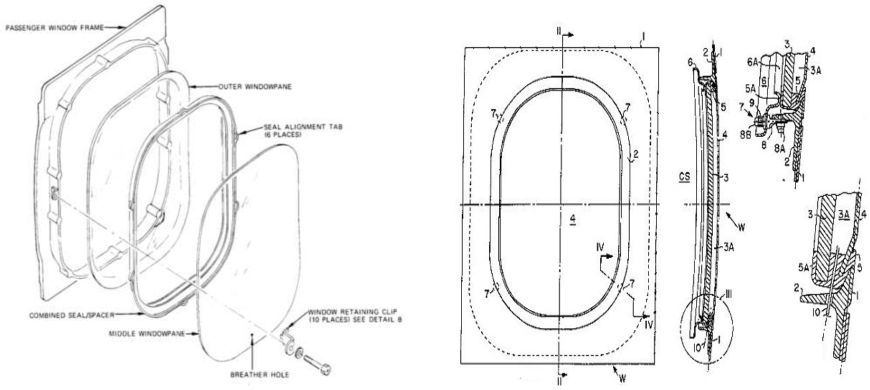

Figure 1: Windows Nomenclature

BRIEF DESCRIPTION OF THE AIRCRAFT WINDOW BLEED (TINY) HOLE

The above figure.1 small window hole is actually called as bleed (tiny) holes, and its edged between 2 other panes of Acrylic material, It means that when we look through an airplane window, you’re actually peering through the three different panes.

The first of these panes – the one you can touch and dirty up with fingerprints – is called a scratch pane. The middle pane is the one with the bleed hole, and the whole system is completed by the outer pane - the most important one, since it protects you from the pressure difference outside.

Before we go into how these windows work, though, it’s important to understand a bit about how air pressure changes when you’re flying.

So, that means that if the outer pane somehow was broken by debris, we'd still have the middle pane to protect us from the lack of air pressure outside. Sure, it'd have a small hole in it, but that's nothing the plane's pressurization system couldn't compensate for.

While this tiny hole plays an important role in keeping us safe, it also helps keep the window panes from fogging up a result of the temperature difference between the inside and outside of the cabin – allowing us to stare out into the clouds.

The determination of stress at each nodal point within a structure is called structural analysis. Stress analysis is help to find out the directions of stresses at different points in the structure and locating the weak nodes where maximum stress concentration happens. This idealization of stresses is known as stress concentration. Stress concentration is measured using Stress Factor, defined as the ratio of maximum stress to the nominal stress and is given by

$$K_t = \frac{\sigma_{max}}{\sigma_{min}} And\ K_s = \frac{\tau_{max}}{\tau_{min}}$$

For normal stresses and shear stresses.

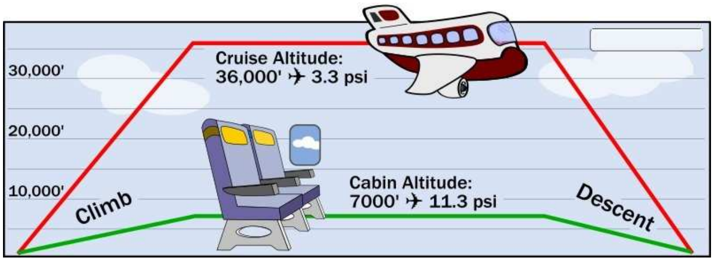

Figure 2: Aircraft at Diffetent Altitude Cruise Condition

RESULTS AND DISCUSSIONS

Stress Analysis was done to obtain the maximum stress concentration for Plexiglas and Acrylic Materials which is at different flight conditions with pressure differences in ground to sea level at pressure 12 psi and high altitude conditions pressure at 14.7 psi. The results are varied from ground conditions to high altitude conditions were listed below figure 5 to Figure 12.

MATERIAL PROPERTIES

Material Used For Window: Plexiglas

SI NO	Plexiglas Properties	
1.	Young's Modulus Pa	2.9e+009
2.	Poisson's Ratio	0.37
3.	Density	1186 kg m3
4.	Tensile strength	80mpa
5.	Modulus of elasticity	3300 mpa
6.	Compressive yield stress	110 mpa
7.	Shear modulus	1700 mpa

Model Statistics	
Nodes	25603
Elements	13826

Number of Nodes and Elements Obtained For FEA Model

- The modeling is done using CATIA V5 and the design specifications were taken from Airbus A380 window with bleed tiny hole diameter 0.7 to 6 mm.

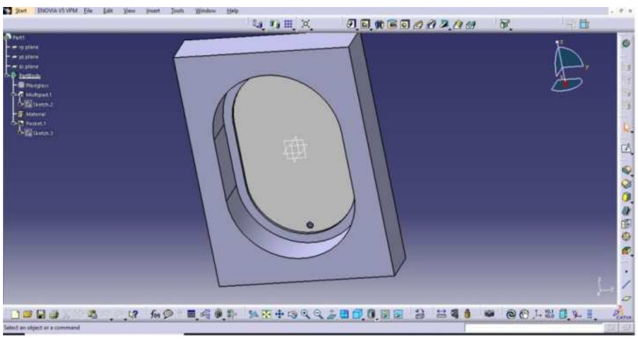

Figure 3: CATIA Model

- The model isimported in ANSYS workbenchanalysisperformedstatic structural analysisupdated engineering data withmaterialproperties and donemechingwithelementedgelength 1 and usedtetra type of mesh. The total number of nodes25603 and the number of elements13826.

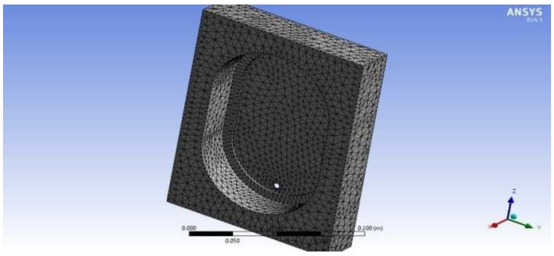

Figure 4: FEA Meshed Model

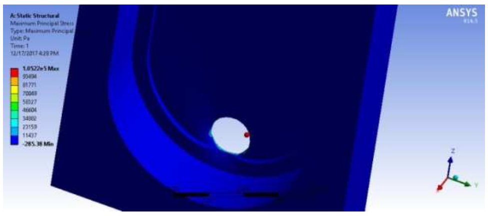

Figure 5: The Maximum Principal Stress

- At sea level the atmospheric pressure 12 PSI

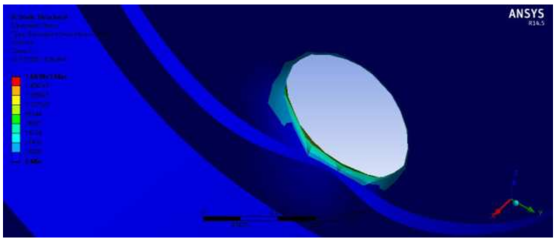

Figure 6: The Equivalent Von Misses Stress

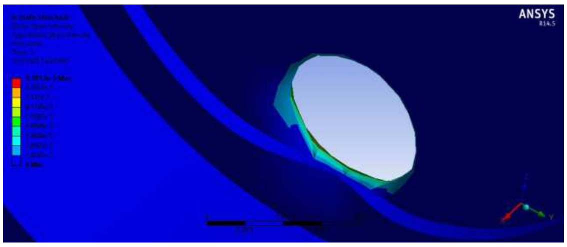

Figure 7: The Stress Intensity

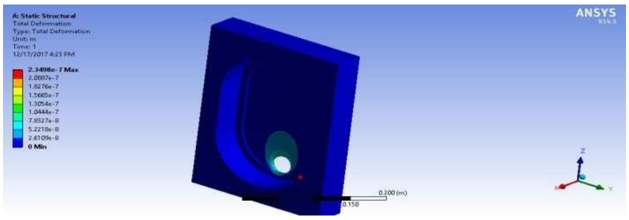

Figure 8. The Total Deformation

- The stress concentrations on window bleed hole at high altitude pressure at 14.7 psi

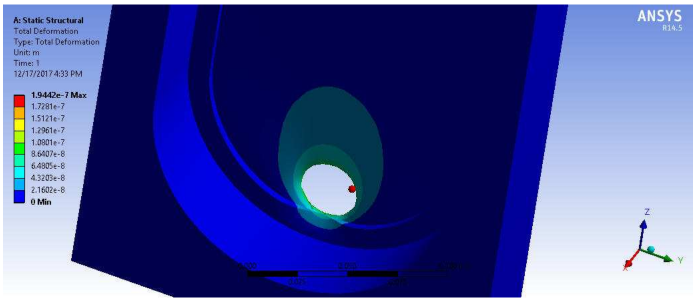

Figure 9: Total Deformation

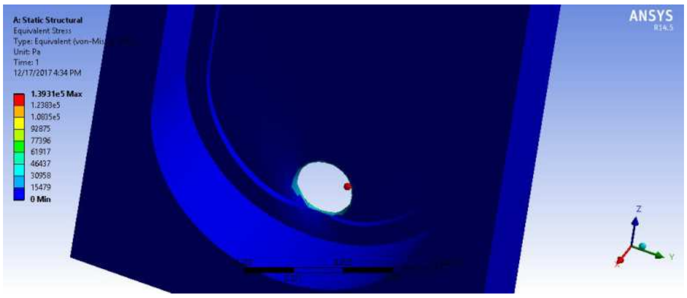

Figure 10: Equivalent Von Misses Stress

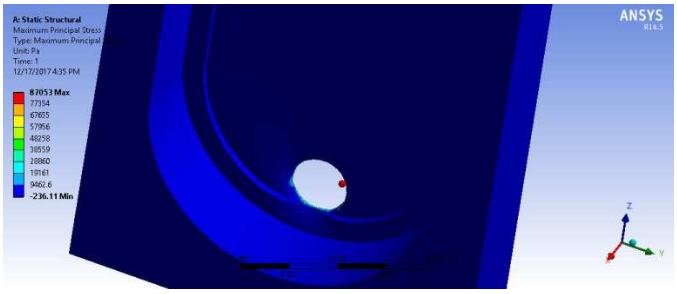

Figure 11: Maximum Principal Stress

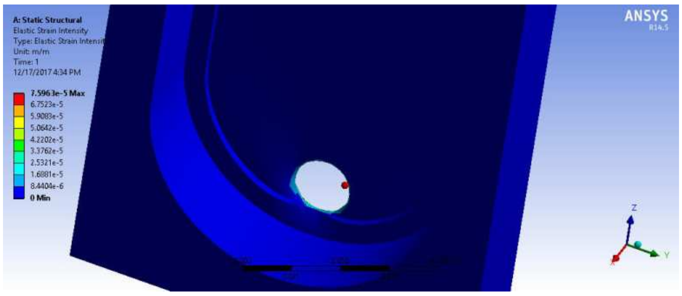

Figure 12: Strain Intensity

STRESS CONCENTRATION RESULTS

SI No		At different cabin pressure condition	
		Max Stress Concentration (N/m2) at 100000 pa 14.7 psi	Max Stress concentration (N/m2) At 12 psi
1.	Total Deformation	2.3498e-7	1.9442e-7
2.	Max Principal stress	1.0525e5	87053
3.	Stress Intensity	9.1813e-5	7.5963e-5
4.	Equivalent Von misses stress	1.6838e5	1.3931e5

CONCLUSIONS

The following are the conclusions deciphered from the results obtained by Finite Element Analysis,

The present method of study helps to analyze the stress concentration around a blended Hole with circular corners, which can be further utilized to study for other geometry as well.

Maximum Stress Concentration at deformation at sea level is 2.3498e-7 N/m2 and at the pressure 14.7 psi, the max stress is 1.9442e-7 & occurs at the bleed hole at high altitude conditions. The aircraft window has a less value of maximum stress concentration factor as compared to bleed hole, because of more curved corners locations. The maximum stress concentration occurred around the window bleed hole while the cabin pressure increased at high altitudes.

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